

cylinders of the third method were prepared by pre-wetting the dry lightweight aggregates with water only prior to adding to the wet mixture that was placed into the mold. The replacement of normal weight sand by lightweight aggregates in the mortar was done in an amount to achieve the same overall addition rate of the polyoxyalkylene alkyl ether, approximately 10%, as that used in the other mortars prepared by the first and second methods.

[0041] After curing for 7 days and 28 days, each concrete cylinder was placed into individual sealable plastic bottles containing sufficient 1 mol/L sodium chloride solution to submerge the specimen. Chloride ion ingress into the mortar cylinders after exposure times of 28 days, 56 days, and 180 days for each cylinder and associated blank was measured. At each exposure time, two cylinders of each type were removed from their chloride solutions and broken down the middle (lengthwise) using the split-cylinder configuration on a universal testing machine. For each specimen, one of the two created faces was sprayed with silver nitrate (AgNO_3) and an image processing software was used to assess the penetration depth of the chloride ions. As of the drafting of this application, exposures through 180 days have been completed. The results obtained as of the drafting of this application with respect to the penetration depths are shown in Table 3.

TABLE 3

Sample, Description	days cured prior to Cl^- exposure		
	28 days Cl^- exposure, mm penetration	56 days Cl^- exposure, mm penetration	180 days Cl^- exposure, mm penetration
1ac, Control Method 1/7	6.68	6.27	7.29
1a, Method 1/7	4.75	5.57	7.38
2ac, Control Method 2/7	5.97	5.44	7.51
2a, Method 2/7	5.37	5.28	7.28
3ac, Control Method 3/7	5.01	5.26	
3a, Method 3/7	4.42	3.64	5.74
1bc, Control Method 1/28	5.06	5.11	7.66
1b, Method 1/28	4.43	4.71	7.03
2bc, Control Method 2/28	4.69	5.23	7.41
2b, Method 2/28	4.38	4.2	6.15
3bc, Control Method 3/28	3.67	4.36	
3b, Method 3/28	3.33	3.72	

[0042] As shown in Table 3, systems employing polyoxyalkylene alkyl ether are shown to unexpectedly exhibit reduction in chloride ion penetration depth. Sample 1a had polyoxyalkylene alkyl ether employed by the first method and sample 1ac was the control prepared by the first method having no polyoxyalkylene alkyl ether, both of which were cured for a total of 7 days prior to contact with the Cl^- solution. The depth of penetration of Cl^- in sample 1a was reduced by more than 25% as compared to control sample 1ac after 28 days of exposure. However, this reduction in Cl^- penetration is not observed after 180 days of Cl^- exposure. Cl^- penetration will be monitored for up to 365 days as this data point may be an outlier.

[0043] Samples 2a and 2ac show that the introduction of polyoxyalkylene alkyl ether into the wet mixture for concrete cylinders that are also exposed to the polyoxyalkylene alkyl ether during a 7 day cure improves the resistance to Cl^- penetration slightly, after 180 days, as compared to only exposing the cylinder to the polyoxyalkylene alkyl ether during the 7 day cure. Sample 2a had polyoxyalkylene alkyl ether in the wet mixture and was cured for 7 days in a solution of

1.1% NaOH/KOH/Ca(OH)_2 and 11% polyoxyalkylene alkyl ether. Sample 2ac, the control sample made by method 2, had no polyoxyalkylene alkyl ether in the wet mixture but was cured in a solution of 1.1% NaOH/KOH/Ca(OH)_2 and 11% polyoxyalkylene alkyl ether.

[0044] Sample 3a shows that the introduction of polyoxyalkylene alkyl ether by pre-wetting the dry lightweight aggregates with a 50% solution of polyoxyalkylene alkyl ether in water prior to adding to the wet mixture substantially improves the resistance of Cl^- diffusivity after 180 days. This sample was cured for 7 days and unexpectedly exhibited over a 33% reduction in Cl^- penetration as compared to sample 1ac, having no polyoxyalkylene alkyl ether. Results of the control, sample 3ac, for the 180 day exposure were not yet available. However, the data shown in Table 3 indicates that this may be an advantageous method of introducing a diffusive transport modifier into concrete.

[0045] Sample 1b has polyoxyalkylene alkyl ether employed by the first method and sample 1bc is the control prepared by the first method having no polyoxyalkylene alkyl ether, both of which were cured for a total of 28 days prior to contact with the Cl^- solution. The depth of penetration of Cl^- in sample 1b was reduced by more than 8% as compared to control sample 1ac after 180 days of exposure. This shows that the diffusive transport modifier unexpectedly retains the characteristic of decreasing ion diffusivity in the pore solution for a longer period of time as compared to the sample 1a, cured for a shorter period of time, 7 days.

[0046] Samples 2b and 2bc show that the introduction of polyoxyalkylene alkyl ether into the wet concrete mixture, for concrete cylinders cured for 28 days in a solution of 1.1% NaOH/KOH/Ca(OH)_2 and 11% polyoxyalkylene alkyl ether, improves the resistance to Cl^- penetration by about 17%, after 180 days. Sample 2bc had no polyoxyalkylene alkyl ether in the wet mixture but was cured for 28 days in a solution of 1.1% NaOH/KOH/Ca(OH)_2 and 11% polyoxyalkylene alkyl ether. Sample 2b had polyoxyalkylene alkyl ether in the wet mixture and was cured in a solution of 1.1% NaOH/KOH/Ca(OH)_2 and 11% polyoxyalkylene alkyl ether for 28 days.

[0047] Sample 3b shows that the introduction of polyoxyalkylene alkyl ether by pre-wetting the dry lightweight aggregates with a 50% solution of polyoxyalkylene alkyl ether in water prior to adding to the wet mixture improved the resistance to Cl^- penetration after 56 days of contact time by about 15% as compared to control sample 3bc. Sample 3bc was prepared by first wetting the dry lightweight aggregate with water. Samples 3b and 3bc were cured for 28 days prior to being contacted with the Cl^- solution. The data in Table 3 shows that this may be an advantageous method of introducing a diffusive transport modifier into concrete.

[0048] As shown in Table 3, the measured penetration depths are significantly less for the samples that were first cured for 28 days, as compared to 7 days, before being exposed to the chloride ion solution. This may be due to the additional hydration achieved between 7 days and 28 days further densifying the mortar microstructure and reducing both its porosity and pore solution connectivity. For the samples cured for 7 days before chloride ion exposure, the penetration depths achieved after either 28 days or 56 days are fairly similar and in some cases, the penetration depth achieved after 56 days is slightly less than that after 28 days. This may be because the samples that only cured for 7 days undergo additional hydration during their chloride ion exposure period. Continuing hydration may lead to reductions in